Accelerating Development of Automotive ADAS SoCs with Certified IP

Synopsys

ABSTRACT

Electronic systems in automobiles are more sophisticated today than ever, and perform key functions to maintain the utmost in safety. These Advanced Driver Assistance Systems (ADAS), whether built-in or after-market, must meet the stringent automotive standards for safety, reliability and quality. For example, automatic emergency braking system must process real-time data and communicate seamlessly over a reliable in-car network to maintain operating modes with more precision than a human operator. SoCs incorporated into such systems must meet ISO 26262 functional safety, AEC-Q100 reliability and automotive quality requirements. This also applies to the entire supply chain, including IP, as they must adhere to these standards.

To accelerate their SoC development as well as safety, reliability and quality assessments, automotive SoC designers see great value in incorporating ASIL Ready Certified IP consisting of automotive safety packages. In this presentation, we will highlight the development and certification of ASIL Ready IP according to ISO 26262, and review the requirements for automotive AEC-Q100 reliability and quality. Learn how you can leverage Synopsys' certified automotive IP portfolio in TSMC's 28-nm and FinFET processes to quickly reach target ASILs and accelerate time-to-volume production.

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Accelerating Development of Automotive ADAS SoCs with Certified IP

TSMC OIP

Ron DiGiuseppe

September, 2017

Agenda

- ADAS & Autonomous Driving SoCs Trends
- Best Practices for ISO 26262 Functional Safety
- ISO 26262 Safety Features
- Automotive Reliability and Quality

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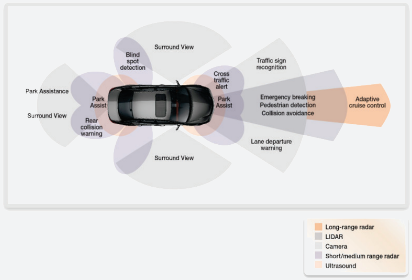
ADAS & Autonomous Driving SoCs

Goal: Reduce Accidents, Injuries & Fatalities

- 6.2 million automotive accidents and 35,000 deaths* in 2015 (in United States)
- About 94% of accidents caused by human error*
  - 2% environment, 2% mechanical, 2% margin error
- ADAS Applications (vision-based)
  - Rear view camera
    - Park assist
  - Front camera
    - Pedestrian Detection
    - AEB (Automatic Emergency Braking)
  - Surround view cameras
  - Interior camera
    - Drowsiness / gaze detection



*Source: Traffic Safety Facts Research Notes, NTSA, Aug 2016 & Feb 2015

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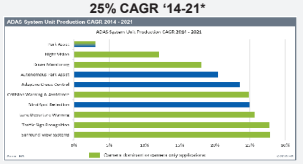
ADAS & Autonomous Driving SoCs Trends

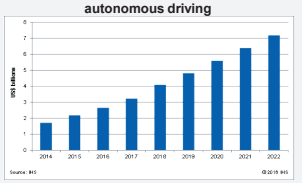
- Sensor fusion: vision, radar, LIDAR, & ultrasonic sensors
- 64-bit processing with heterogeneous co-processing
- Embedded vision processors
  - Latest vision algorithms e.g. CNN
- Deep-learning
- Advanced connectivity:
  - Ethernet AVB/TSN, LPDDR4, MIPI, PCIe, USB, Bluetooth
  - 5G and 802.11p
- Advanced process nodes
  - 16FFC & N7-nm processes
- ISO 26262 safety critical

"SoCs supporting safety-critical ADAS functions are predicted to grow in volumes with a **CAGR of 48%** in the next 3 years"
- Luca De Ambroggi, IHS Markit, July 2017

ADAS: Fastest growing automotive application: 25% CAGR '14-21*



Semiconductor revenue for ADAS and autonomous driving



** Trends and Opportunities in Driver Assistance and Automated Driving*, IHS Automotive Sep 2015
** Source: ADAS Semiconductor Market Tracker, IHS, H1 2016*

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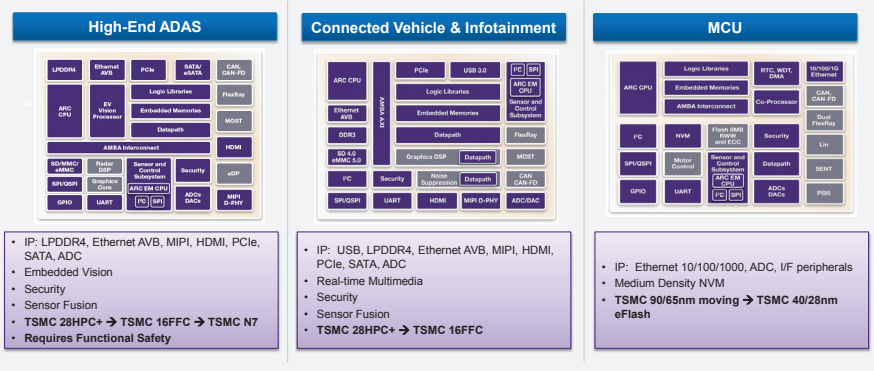
Automotive Applications Require Different SoC Architectures



- IP: LPDDR4, Ethernet AVB, MIPI, HDMI, PCIe, SATA, ADC
- Embedded Vision
- Security
- Sensor Fusion
- **TSMC 28HPC+ → TSMC 16FFC → TSMC N7**
- **Requires Functional Safety**

- IP: USB, LPDDR4, Ethernet AVB, MIPI, HDMI, PCIe, SATA, ADC
- Real-time Multimedia
- Security
- Sensor Fusion
- **TSMC 28HPC+ → TSMC 16FFC**

- IP: Ethernet 10/100/1000, ADC, I/F peripherals
- Medium Density NVM
- **TSMC 90/65nm moving → TSMC 40/28nm eFlash**

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ADAS & Autonomous Driving SoCs Trends

Best Practices for ISO 26262 Functional Safety

ISO 26262 Safety Features

Automotive Reliability and Quality

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ADAS SoCs Require ISO 26262 Functional Safety Compliance

SGS TÜV SAAR ASIL D READY Functional Safety

ISO 26262 CERTIFIED

Electronics Failures Can Have Hazardous Impact

- ASIL A/B/C/D defines the level of safety required; ISO 26262 defines the processes and standards
- Goal is to minimize the susceptibility to random hardware failures by:
  - Defining the functional requirements
  - Applying rigor to the development process
  - Taking necessary design measures
  - Applying systematic analysis methods
- Compliance certifications for SoCs granted by accredited providers
  - Training
  - Product & process reviews
  - Product assessments & certifications

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Best Practices for ISO 26262: FMEDA Generation

- Concurrent reviews by multiple engineers eliminate bias
- Safety manager participation as process audit
- One review participant documents key decisions
- Complete block-by-block analysis
- Gate count numbers will be heavily configuration and technology dependent.
  - SEooC*, reasonable automotive use model assumptions should be made.
  - Customer specific, utilize data from the exact customer configuration and technology.

* SEooC: Safety Element out of Context

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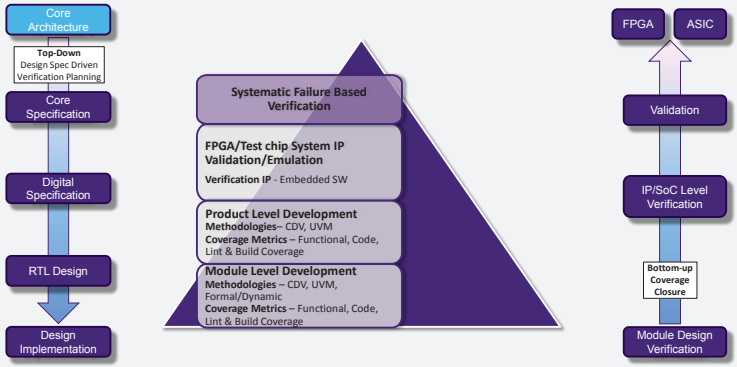
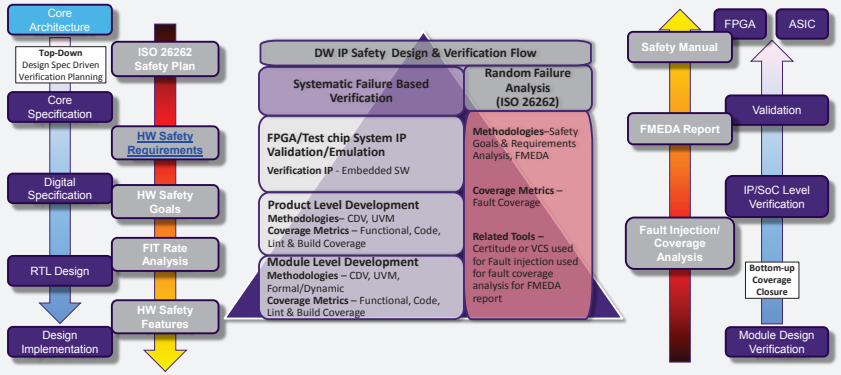
HW Design & Verification Flow

ISO 26262 Ready IP



HW Design & Verification Flow

ISO 26262 Ready IP



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ADAS & Autonomous Driving SoCs Trends

Best Practices for ISO 26262 Functional Safety

ISO 26262 Safety Features

Automotive Reliability and Quality

ISO 26262 Guideline for Safety Features to Detect Failures of Elements

Diagnostic Type	Effectiveness
HW Redundancy	High - 99%
Configuration Register Test	High - 99%
EDC* on Memory	High - 99%
Combination of Timeout monitoring, Frame Counter & information Redundancy	High - 99%
Self-test supported by Hardware	High - 99%
Multi-bit HW redundancy	Medium - 90%
Timeout monitoring	Medium - 90%
Frame Counter	Medium - 90%
Information Redundancy	Medium - 90%
Parity Bit - per Word	Low - 60%

Source: ISO 26262-5 Annex D *EDC: Error-Detection-Correction Codes

Internal Safety Features Implemented by Synopsys

Category	New Safety Mechanism in IP RTL
Protection Mechanisms	Protection in APB interface programming interface
	Write pointer protection in Elastic Buffer
	EDC protection on the header
	Parity protection on datapath - using byte parity
	Parity protection on configuration registers
	ECC protection on write/read into memories
Replication	Duplicating key modules - comparing outputs
	Triplicate the wordcount register with voting logic
Various	Concatenate states registers and add parity check to word
	Check validity of single cycle pulses in key modules
	System informed of errors via various dedicated interrupts
	One hot state machine protection for bad States

Features added to support functional safety

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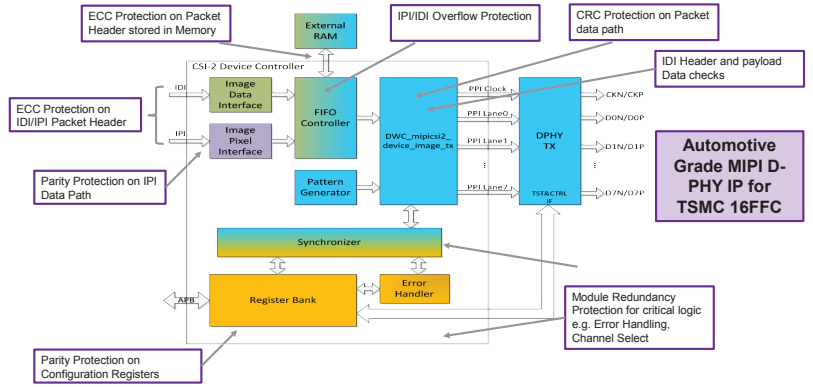
Example of Automotive Safety Features: MIPI CSI-2 Device Controller & MIPI D-PHY for TSMC 16FFC

ASIL B READY



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ISO 26262 Safety Features

Automotive Reliability and Quality

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Synopsys Automotive Grade IP

Reduce Risk and Accelerate Qualification for Automotive SoCs

Functional Safety	Accelerate ISO 26262 functional safety assessments to help ensure designers reach target ASIL levels
Reliability	Reduce risk & development time for AEC-Q100 qualification of SoCs
Quality	Meet quality levels required for automotive applications

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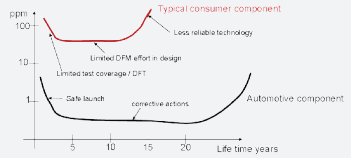
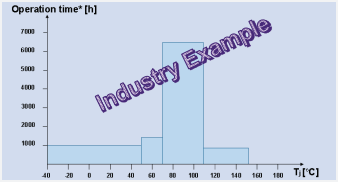
Designing IP in TSMC 16FFC for Automotive Reliability

- Synopsys productizes hard IP for automotive apps
- Target low ppm automotive reliability vs consumer



- Synopsys has defined internal Reference Temp Profiles based on multiple automotive industry engagements



Duration (h)	Percentage (%)	Tj component (°C)
1000	10	48
1600	16	71
6500	65	108
890	9	150

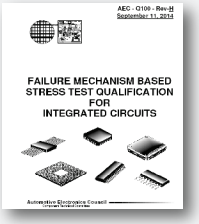
Example Temperature Mission Profile*

* Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications, ZVEI, May 2015

Designing & Testing IP for AEC-Q100 Qualification

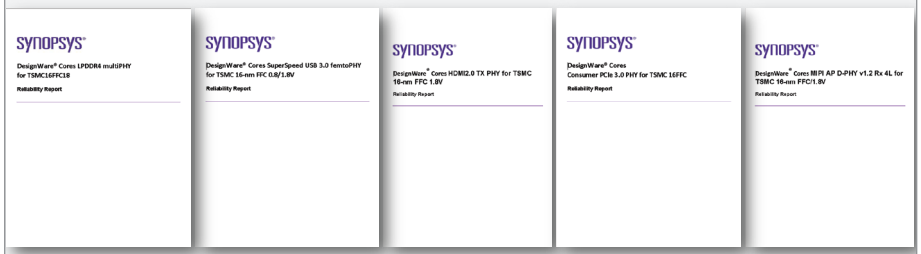
Reduce Risk & Development Time for AEC-Q100 Qualification

- All automotive SoCs need AEC-Q100 qualification
  - Fault Sim & Fault Grading
  - Accelerated environment stress test
  - Accelerated lifetime simulation tests
  - Reliability tests such as electromigration
  - Electrical verification tests such as ESD, latch-up
- Some tests are SoC-level only
  - Wire bond shear test for packaging
- Not all tests apply to all IP
  - Example: ESD testing for LPDDR4 PHY but not for embedded memories



Automotive Electronics Council
Component Technical Committee

Automotive IP AEC-Q100 Testing Report: MSIP PHYs for TSMC 16FFC



LPDDR4 MultiPHY v2 | USB 3.0 | HDMI2.0 Tx | PCIe 3.0 | MIPI D-PHY

Interface IP Portfolio and Foundation IP Meet Stringent AEC-Q100 Grade 1 Temp Requirements

- Delivers higher reliability for automotive SoCs
- AEC-Q100 Designed and Tested
- Foundation IP
  - Designed for 1 DPPM & 125C ambient (150C junction) temps
  - Delivers superior PPA TSMC 16FFC & 28HPC+
  - In-house HTOL testing capabilities available
- Interface IP Portfolio
  - LPDDR4, MIPI D-PHY, PCIe 3.1 & Ethernet on 16FFC
  - IP with available test reports meets Grade 1 temps (-40C to 125C ambient, 150C junction) & mission profile requirements

Quality Management: Quality Manuals, Control of Documents/Records…

Delivering Automotive Quality IP to Meet Customer Requirements

Define
- Define Quality requirements & objectives
- Plan deployment

Implement
- Implement process controls
- Collect test data

Analyze
- Propose effective counter-measures

Standardize
- Standardize procedures
- Continuous improvement

Synopsys Quality Management Deliverables

Customer Satisfaction Metrics	
Product Quality	*What is your overall satisfaction with the product?*
Support Quality	*What is your overall satisfaction with the product support?*
Loyalty	*Are you planning to use the product for your next design?*
Referenceability	*Would you recommend the product to another potential user?*
Usability	*What is your overall satisfaction with the usability of product?*
Quality Trend	*How would you rate overall Product quality trend over last year?*

- DFMEA Reports
- Infrastructure for operational management & improvement
  - Compliance reports
  - Dashboard reports
  - Repository for tracking IP development & releases
- Internal and customer audits

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Industry Example of DFMEA Spreadsheet

Item	Function(s)	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Cause(s) of Failure	Occurrence	Current Design Controls (Prevention/ Detection)	Detection	RPN	Recommended Action(s)	Responsible Person / Target Completion Date	Actions Taken / Effective Completion Date	Revised Rankings: Severity	Occurrence	Detection	RPN

Describe the function to be analyzed

Describe how item could potentially fail

State the effects of the failure in terms of the item being analyzed

Identify potential causes of the item not performing its intended function

Risk Priority Number RPN=S*O*D

Synopsys provides DFMEAs for automotive IP in TSMC 16FFC

Source: Potential Failure Mode ad Effects Analysis (FMEA), 4th ed, 2008, AIAG

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DesignWare IP Portfolio for Automotive Applications

Accelerates Qualification of Automotive SoCs

IP Portfolio	
Ethernet AVB and TSN	Embedded Memories
LPDDR4	Logic Libraries
MIPI CSI-2/DSI	PCI Express
HDMI	Mobile Storage
USB Host & Device	Datapath IP
ARC EM & HS Processors	Embedded Vision Processors
Security: Encryption & Decryption	Sensor & Control IP Subsystem
NVM	Data Converters
Star Memory System	Star Hierarchical Sys.

ASIL B & D Ready IP Designed for Automotive w/ AEC-Q100 Testing and **Automotive Quality Management** targeting ADAS, infotainment, and MCU applications

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ASIL Ready DesignWare IP Accelerates Path to ISO 26262 Compliance

ISO 26262 CERTIFIED

DesignWare IP	ASIL Functional Safety Certification	Grade 1 & 2 Temperature PHYs, Embedded Memories, NVM
ARC EM SEP	ASIL D	
ARC EM Safety Island	ASIL D	
Embedded Memories 16FFC	ASIL D	Grade 1 & 2
Star Memory System (SMS)	ASIL D	
Star Hierarchical System (SHS)	ASIL D	
NVM	ASIL D	Grade 1 & 2
Ethernet QoS	ASIL B	
PCIe 4.0 Controller, PCIe 3.1 Controller & 16FFC PHY	ASIL B	Grade 1 & 2
USB 3.0 Controller	ASIL B	
LPDDR4 Controller & MultiPHY v2	ASIL B	Grade 1 & 2
MIPI CSI-2 Controller & 16FFC PHY	ASIL B	Grade 1 & 2
MIPI DSI	Compliance in progress or planned	
Sensor & Control Subsystem	Compliance in progress or planned	
Security IP	Compliance in progress or planned	
EV Vision Processors	Compliance in progress or planned	

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Summary

- **ADAS:** Fastest growing automotive application: 25% CAGR '14-21
- Synopsys provides ISO 26262 Safety Features integrated into Automotive IP portfolio
  - DDR, Ethernet, USB, MIPI CSI-2/DSI, HDMI, PCIe IP
  - Memories, Logic Libraries and Test
  - Analog and NVM
  - ARC EM & ARC Safety Island with Safety Enhancement Package
  - Sensor & Control IP Subsystem
  - VDKs, IP Prototyping Kits
- Grade 1 & 2 temperature PHYs, embedded memories and NVM
- ASIL Ready ISO 26262 ASIL Ready IP, AEC-Q100 Verified & Testing, Automotive Quality Management

www.synopsys.com/designware

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